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(19)

(54) IMPROVEMENTS IN OR RELATING TO ELECTRIC DISCHARGE LAMPS

(71) We, THE GENERAL ELECTRIC COMPANY LIMITED, of 1 Stanhope Gate, London, W1A 1EH, a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to electric discharge lamps of the type, usually referred to as high pressure sodium vapour electric discharge lamps, comprising a tubular discharge envelope formed of light-transmissive alumina and containing a filling of sodium, rare gas and usually at least one additional metal, especially mercury, in quantities such that in operation of the lamp a pressure exceeding 400 torr is developed within the envelope, and comprising also, disposed within the end regions of said envelope, two electrodes between which an electric discharge is arranged to pass in operation of the lamp. The invention is also concerned with a method of manufacturing lamps of the form described.

Hitherto the tubular discharge envelopes of such high pressure sodium lamps have usually been formed of translucent sintered polycrystalline alumina containing up to 1% by weight of another refractory oxide such as magnesium oxide, and have been closed at both ends by closure members formed of a refractory metal or alloy having thermal expansion characteristics substantially matching those of the alumina of the tube, and resistant to sodium vapour attack, niobium being a particularly suitable metal for this purpose. The closure members each carry one of the electrodes, and an additional metal member which is attached to the exterior of the closure member for connection of the electrode to a source of electric current supply, one of these external members usually being an exhaust tube fitted into an aperture in the closure member. The metal closure members can be sealed to the ends of the alumina tube by means of a suitable sealing glass, or by means of an active alloy brazing material, suitably composed of zirconium, titanium and vanadium.

It has also been proposed to close the ends of the polycrystalline alumina tube with polycrystalline alumina closure members through which elongated refractory metal members are sealed, to support the electrodes and provide current conducting leads thereto, these metal members again suitably being of niobium, and being sealed to the alumina closure members by means of a calcium aluminate glass. However, it has been found that the calcium aluminate glass reacts with sodium metal which condenses in the relatively cool end regions of the envelope, resulting in clean-up of sodium from the filling, which is responsible for the occurrence of changes in the electrical characteristics of the lamp and colour of the emitted light during the life of the lamp.

It is an obect of the present invention to provide an improved form of high pressure sodium vapour electric discharge lamp, having polycrystalline alumina closure members with refractory metal members sealed therethrough as aforesaid, wherein the risk of reaction between condensed sodium and the material of the seals between the alumina closure members and said metal members can be reduced or eliminated.

According to the invention, in a high pressure sodium vapour electric discharge lamp, as hereinbefore defined, the tubular discharge envelope formed of light transmissive alumina is hermetically closed at each end by means of a closure structure comprising a cylinder of polycrystalline alumina, having an axial bore and having an annular recess formed in the inner end face of the cylinder and radially separated from the bore by an annulus of the alumina of

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the cylinder, and, sealed into the said bore of the alumina cylinder, an elongated refractory metal member to which an electrode is attached, the inner end of the said metal member and the outer end of the electrode attached thereto being located within the bore of the alumina cylinder.

It will be understood that the expression " inner end ", used herein with reference to the alumina cylinder and annulus, the metal member sealed into the cylinder bore, and the electrode, means that end of such member which is directed towards the interior of the discharge envelope, and the " outer end " of the electrode is that end of the electrode which is directed away from the interior of the discharge envelope.

Preferably each of the said refractory metal members is formed of niobium and is sealed into the bore of the polycrystalline alumina cylinder with a calcium aluminate sealing glass. The said metal members may be rods but are preferably tubular, the inner ends of the metal tubes being closed around and brazed to the outer ends of the electrodes, which can be of conventional form consisting of a tungsten rod with a tungsten wire coil wound around the inner end of the rod and retaining a small amount of electron emissive material. The metal members suitably extend beyond the outer ends of the respective alumina cylinders, to provide conducting leads to, as well as supports for, the electrodes.

The annular recesses in the inner end faces of the polycrystalline alumina cylinders serve as reservoirs for sodium, and possibly for any other metal, such as mercury, present in the envelope filling, since the recesses are so positioned that most of the metal which condenses in the cooler end regions of the envelope in operation of the lamp will collect in the recesses. The alumina annulus between the annular recess and the axial bore in each cylinder thus serves as a shield preventing access of the condensed sodium metal to the seal between the niobium tube (or other refractory metal member) and the alumina cylinder: the presence of such a shield is especially advantageous when the material employed for forming this seal is calcium aluminate glass which, as mentioned above, is particularly prone to attack by sodium metal. The annular recess may be situated between the inner and outer cylindrical surfaces (that is to say the bore wall and the outer surface) of the alumina cylinder, so as to leave an outer annulus of alumina, as well as the inner annulus screening the recess from the bore, the outer annulus being sealed to the adjacent end of the tubular envelope. Alternatively, the annular recess may extend to the periphery of the cylinder, the annulus of alumina around the bore thus appearing as an extension from the main body of the alumina cylinder. Either of these forms of alumina component may, if desired, be additionally recessed in the peripheral region, the end of the envelope tube being sealed into this additional recess.

It will be appreciated that, for the reason indicated above, the use of calcium aluminate glass for sealing the polycrystalline alumina cylinders to the ends of the envelope tube should preferably be avoided. The envelope tube may also be formed of polycrystalline alumina, and in this case the tube and the end closure cylinders may conveniently be joined together by sintering.

However, in a preferred form of the lamp in accordance with the invention, the tubular discharge envelope is formed of transparent crystalline alumina, and the ends thereof are sealed to the polycrystalline alumina cylinders of the closure structures by means of interposed layers of an active alloy containing titanium.

An " active alloy " is an alloy which can be employed for sealing two components together by virtue of the fact that at least one constituent of the alloy reacts with the material of each of the components. Titanium reacts with alumina, and thus an alloy containing titanium can form a strong bond between two alumina components. The alloy used for sealing the polycrystalline alumina cylinders to the crystalline alumina envelope tube, in the above-mentioned preferred form of lamp, preferably consists of zirconium, vanadium and titanium.

It will be understood that the term " crystalline ", as used herein, means that the material so described either is monocrystalline or is composed of a small number of large crystals, in contrast to " polycrystalline " material, which is sintered ceramic material composed of a multiplicity of small crystals. The transparent crystalline alumina tube constituting the envelope of a lamp in accordance with the preferred form of the invention suitably consists of a cut length of corundum tubing, which may be fabricated by a known crystal growing technique comprising pulling from a melt a film supported on a tubular member, the tubing so formed being mono-crystalline or consisting of two or three large crystals grown simultaneously.

It will also be understood that the polycrystalline alumina referred to herein, which is formed by sintering alumina powder, may contain a small proportion, for example 1% by weight, of magnesium oxide or other suitable refractory oxide additive for controlling the grain growth of the alumina, in known manner. The recessed alumina cylinders for use in the closure structures of the lamp of the invention are readily produced by sintering alumina powder under

pressure in a die of appropriate shape.

It has already been proposed to employ transparent crystalline alumina in the form of corundum tubing for the construction of the discharge envelopes of high pressure sodium lamps, this material having the advantage, over sintered polycrystalline alumina, of higher light transmissivity, resulting inimproved efficacy of the lamps. However, difficulty has been experienced in sealing refractory metal closure members to the ends of corundum tubes by the known techniques since, owing to the brittle nature of corundum and stresses usually present in the corundum crystals, the ends of the tubes tend to develop cracks or leaks during the sealing process. This difficulty is overcome by the use of a closure structure in accordance with the present invention, since sealing of the polycrystalline alumina cylinders to the ends of a corundum tube does not result in cracking of the corundum.

In manufacturing a lamp in accordance with the invention, the cylindrical polycrystalline alumina components of the closure structures are preferably sealed to the ends of the envelope tube before the refractory metal members are inserted into the bores of the alumina cylinders.

A preferred method of manufacturing a lamp according to the invention includes the steps of sealing a recessed polycrystalline alumina cylinder as aforesaid to each end of a transparent crystalline alumina tubular envelope by means of an interposed layer of a zirconium - vanadium - titanium alloy, attaching an electrode to one end of each of two tubes of refractory metal, preferably niobium, which fit loosely within the bores of the polycrystalline alumina cylinders, inserting a first refractory metal tube-electrode assembly into the bore of a first one of said polycrystalline alumina cylinders and sealing the refractory metal tube within said bore by means of a suitable sealing glass (calcium aluminate glass in the case of a niobium tube), introducing a quantity of sodium, and of any other desired metal or metals, required for the lamp filling, into the envelope through the bore of the second of said polycrystalline alumina cylinders, inserting the second refractory metal tube-electrode assembly into the bore of the said second alumina cylinder, evacuating the envelope and introducing the required rare gas filling into the envelope through the annular space around the second refractory metal tube in the bore of the second alumina cylinder, and sealing the second refractory metal tube into the bore of the second alumina cylinder by means of a sealing glass.

Some specific embodiments of high pressure sodium vapour electric discharge lamps in accordance with the invention, and the method which we have employed for their manufacture, will now be described by way of example with reference to the accompanying diagrammatic drawing, in which

Figure 1 shows, in part-sectional elevation, a lamp having recessed polycrystalline alumina end closure members of one form, sealed to a tubular envelope of transparent crystalline alumina, and

Figure 2 is a part-sectional elevation of a lamp similar to that of Figure 1, with the exception that the polycrystalline alumina end closure members are of a different form.

Like parts in the two Figures of the drawings are indicated by the same reference numerals.

The lamp shown in Figure 1 comprises a tubular discharge envelope 1 formed of corundum, containing a filling of sodium, mercury and rare gas, and end closure structures each consisting of a polycrystalline alumina cylinder 2, 3 and a niobium tube 4, 5, sealed into the bore, 6, 7, of the alumina cylinder and supporting an electrode 8, 9. The polycrystalline alumina cylinders have annular recesses 10, 11 formed in their inner end faces in such a position that alumina annuli 12, 13 are established between the recess and the bore in each case. The niobium tubes 4, 5 are sealed into the bores 6, 7 by means of a calcium aluminate sealing glass: in the drawing, the completed seal is shown, at 14, in the case of one closure structure 2, 4, and the other closure structure 3, 5 is shown assembled, with a washer 15 of the sealing glass *in situ*, prior to the formation of the seal. The polycrystalline alumina cylinders 2, 3 are sealed to the ends of the corundum tube 1 by means of interposed layers 16 of a zirconium-vanadium-titanium alloy. The electrodes 8, 9 are of conventional form, consisting of silicated tungsten rods each with a tungsten wire coil, retaining a small quantity of electron-emissive material, wound on the inner end.

In the manufacture of the lamp shown in Figure 1, each of the electrodes 8, 9 is attached to one of the niobium tubes 4, 5 by pinching the inner end of the tube over the outer end of the electrode and brazing the co-operating ends of the tube and electrode together with titanium, as shown at 17. The polycrystalline alumina cylinders 2, 3 are sealed to the respective ends of the corundum tube 1 in a single operation, by inserting between each end of the tube and the co-operating surface of the cylinder three thin washers composed respectively of the metals zirconium, vanadium and titanium and of different thicknesses to give the required relative proportions of the metals to form an alloy consisting of 68% zirconium, 18% titanium and 14% vanadium, by

weight, then supporting the whole assembly vertically in a closed vessel, with a load of approximately 10 Kg applied to the top of the uppermost alumina cylinder, heating in vacuum so that the temperature is raised to 1500°C - 1550°C in about ten minutes, and allowing the assembly to cool to room temperature while the load thereon is retained.

The niobium tube-electrode assembly 4, 8 is then inserted into the bore 6 of the alumina cylinder 2, so that the inner end of the niobium tube does not extend to the inner end of the bore, a washer of calcium aluminate glass (similar to that shown at 15) is placed over the protruding end of the tube 4 to lie on the outer surface of the alumina cylinder 2, and the closure assembly is heated to 1350°C in an atmosphere of argon at a pressure of 40 torr: some of the molten glass penetrates into the small annular space between the niobium tube and the wall of the bore 6, to form an hermetic seal in addition to that formed between the niobium tube and the outer surface of the alumina cylinder.

A quantity of sodium amalgam is then introduced into the envelope 1 through the bore 7 of the alumina cylinder 3, the second niobium tube-electrode assembly 5, 9 is inserted into the bore 7 and the glass washer 15 is placed in position around the tube 5, the envelope is evacuated and the required rare gas filling is introduced, through the annular space between the tube 5 and the wall of the bore 7, and the glass seal between the niobium tube 5 and the alumina cylinder 3 is formed as before, by heating in an atmosphere consisting of argon, krypton or xenon, the gas used being the same as that used for the envelope filling. A suitable sealing glass composition consists of 33.1 mol.% alumina, 51.4 mol.% calcium oxide, 9.5 mol.% magnesium oxide, 4.2 mol.% barium oxide and 1.8 mol.% boric oxide. Finally the outer ends of the niobium tubes 4, 5 are pinched to form tags to which leads for connection to a source of electric current supply can be attached.

In a specific example of a lamp of the form shown in Figure 1 and manufactured as described above, the corundum tube 1 was 120 mm long and had an external diameter of 9 mm and a wall thickness of 0.5 to 0.75 mm. The polycrystalline alumina cylinders 2, 3 were 14 mm long and 9 mm in diameter, with bores of 3.0 mm diameter and recesses 10, 11 of depth 6.0 mm and width 1.0 mm, the alumina annuli 12, 13 being 1.0 mm thick. The niobium tubes 4, 5 had external diameters of 3.0 mm and wall thickness of 0.1 mm. and the electrode rods were 12 mm long and 1.0 mm in diameter. The filling consisted of 10 mgm of sodium, 30 mgm of mercury, and xenon at a room temperature pressure of 30 to 60 torr.

The lamp shown in Figure 2 and the method employed for its manufacture are similar to those described with reference to Figure 1, except that the polycrystalline alumina closure members 18, 19 are of modified form, the annular recesses 20, 21 formed in the inner ends of the cylinders in each case extending to the periphery of the cylinder and terminating in an additional small recess 22, 23 adapted to receive the metal washers and the ends of the corundum tube 1, for forming the seals between the latter and the polycrystalline alumina closure members. In a specific example of a lamp of this form, the dimensions of the various components, and the quantities of constituents of the envelope filling, were the same as those described with reference to the lamp of Figure 1, apart from the modifications of slightly increased width of the recesses 20, 21 and the presence of the peripheral recesses 22, 23.

WHAT WE CLAIM IS:—

1. A high pressure sodium vapour electric discharge lamp, as hereinbefore defined, wherein the tubular discharge envelope formed of light-transmissive alumina is hermetically closed at each end by means of a closure structure comprising a cylinder of polycrystalline alumina, having an axial bore and having an annular recess formed in the inner end face of the cylinder and radially separated from the bore by an annulus of the alumina of the cylinder, and, sealed into the said bore of the alumina cylinder, an elongated refractory metal member to which an electrode is attached, the inner end of the said metal member and the outer end of the electrode attached thereto being located within the bore of the alumina cylinder.

2. A lamp according to Claim 1, wherein each of the said refractory metal members is formed of niobium and is sealed into the bore of the polycrystalline alumina cylinder with a calcium aluminate sealing glass.

3. A lamp according to Claim 1 or 2, wherein each of the said refractory metal members is a tube, the inner end of which is closed around and brazed to the outer end of an electrode rod.

4. A lamp according to Claim 1, 2 or 3, wherein the said refractory metal members extend beyond the outer ends of the respective alumina cylinders, to provide conducting leads to the electrodes.

5. A lamp according to any preceding Claim, wherein in each of said closure structures the annular recess in the inner end face of the alumina cylinder is situated between the inner and outer cylindrical surfaces of the said cylinder, so as to leave an outer annulus of alumina, and the said outer annulus is sealed to the adjacent end of the

tubular discharge envelope.

6. A lamp according to any of the preceding Claims 1 to 4, wherein in each of said closure structures the annular recess in the inner end face of the alumina cylinder extends to the periphery of the cylinder.

7. A lamp according to Claim 5 or 6, wherein each said alumina cylinder is additionally recessed in the peripheral region, and the adjacent end of the tubular discharge envelope is sealed into the additional recess.

8. A lamp according to any preceding Claim, wherein the tubular discharge envedope is formed of polycrystalline alumina.

9. A lamp according to Claim 8, wherein the tubular discharge envelope and the polycrystalline alumina cylinders of the end closure structures are joined together by sintering.

10. A lamp according to any of the preceding Claims 1 to 7, wherein the tubular discharge envelope is formed of transparent crystalline alumina, as hereinbefore defined.

11. A lamp according to Claim 10, wherein the tubular discharge envelope consists of a length of corundum tubing.

12. A lamp according to Claim 10 or 11, wherein the ends of the tubular discharge envelope are sealed to the polycrystalline alumina cylinders of the closure structures by means of interposed layers of an active alloy, as hereinbefore defined, containing titanium.

13. A lamp according to Claim 12, wherein the said active alloy layers consist of zirconium, vanadium and titanium.

14. The method of manufacturing a lamp according to any preceding Claim, wherein the polycrystalline alumina cylinders of the closure structures are sealed to the ends of the tubular discharge envelope before the refractory metal members are inserted into the bores of the alumina cylinders.

15. The method of manufacturing a lamp according to Claim 10 or 11, which includes the steps of sealing a said recessed polycrystalline alumina cylinder to each end of a transparent crystalline alumina tubular envelope by means of an interposed layer of a zirconium-vanadium-titanium alloy, attaching an electrode to one end of each of two refractory metal tubes which fit loosely within the bores of the polycrystalline alumina cylinders, inserting a first refractory metal tube-electrode assembly into the bore of a first one of said polycrystalline alumina cylinders and sealing the refractory metal tube within said bore by means of a sealing glass, introducing a quantity of sodium and of any other desired metal or metals, required for the lamp filling, into the envelope through the bore of the second of said polycrystalline alumina cylinders, inserting the second refractory metal tube-electrode assembly into the bore of the said second alumina cylinder, evacuating the envelope and introducing the required rare gas filling into the envelope through the annular space around the second refractory metal tube in the bore of the second alumina cylinder, and sealing the second refractory metal tube into the bore of the second alumina cylinder by means of a sealing glass.

16. The method according to Claim 15, wherein the said refractory metal tubes are formed of niobium and the said sealing glass is calcium aluminate glass.

17. A high pressure sodium vapour electric discharge lamp according to Claim 1, substantially as shown in, and as hereinbefore described with reference to, Figure 1 or Figure 2 of the accompanying drawing.

18. The method of manufacturing a lamp according to Claim 16, carried out substantially as hereinbefore described by way of example with reference to Figure 1 or Figure 2 of the accompanying drawing.

For the Applicants,
J. E. M. HOLLAND,
Chartered Patent Agent.

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1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

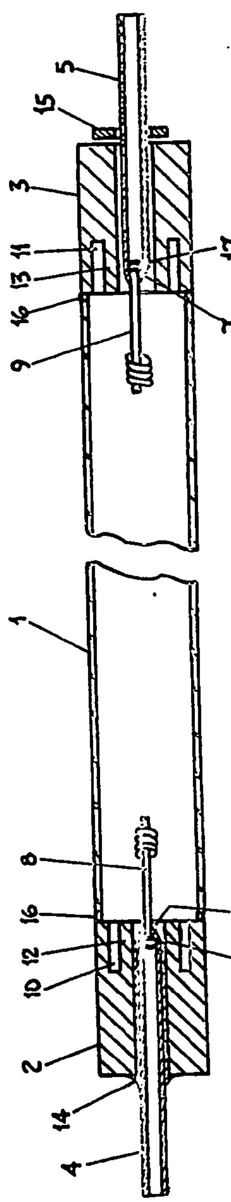

FIG.1.

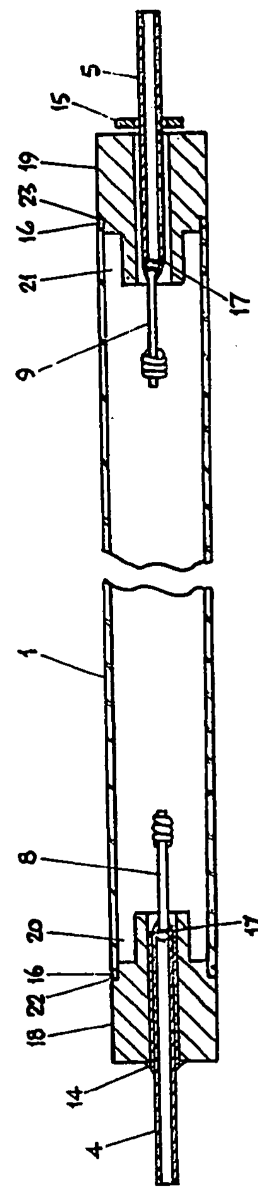

FIG.2.

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